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GEOLOGY OF CHIAPAS, TABASCO AND THE PENINSULA OF YUCATAN.¹

STRATIGRAPHY.

IF one observes the general features of the distribution of the geological formations which constitute the states of South-eastern Mexico he soon finds that in the states of Chiapas and Tabasco there are various distinct geological zones; a very ancient one in the south of Chiapas formed of plutonic rocks and Palæozoic formations; another, more modern, in the middle and northern regions made up of Mesozoic and Tertiary formations. At the foot of each of the above mentioned zones Quaternary deposits are found, forming great plains slightly elevated above sea level. In the Peninsula of Yucatan there is not such a variety of geological formations. Nearly all that extensive region presents a uniform character, which shows that there have not been there so many geological disturbances as in the mountainous regions of Chiapas, and that these deposits were formed under different conditions. In treating of the orography I will speak more in detail of these differences. Yucatan is a part of the earth which has not participated in the dislocations and depressions that the sedimentary deposits, both Palæozoic as well as Cretaceous and Tertiary, of Chiapas have undergone, resulting in the development of mountain chains in that state. The strata are almost horizontal or a little inclined in Yucatan,

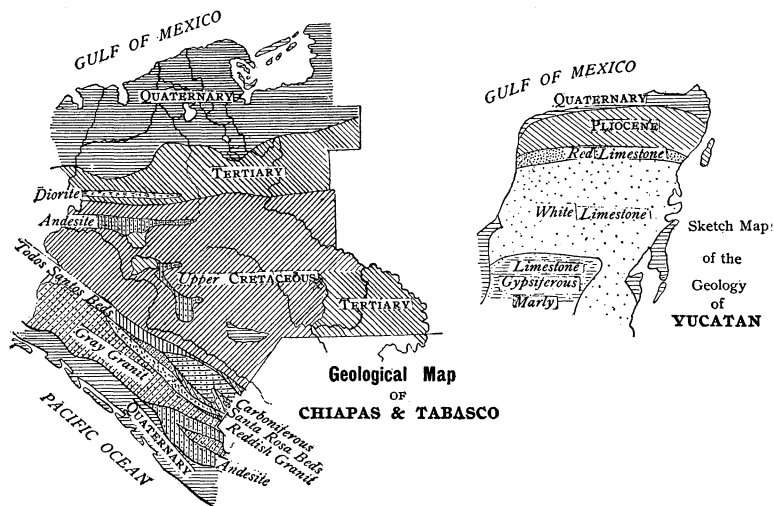
¹ Boletín del Instituto Geológico de México, Num. 3, La Geografía Física y la Geología de la Península de Yucatan, Mexico. 1896. Roy. 4°, 57 pp., 2 pl. of sections and 3 folded maps.

The work from which the following translation is taken is divided into five parts, viz., geology, orography, hydrography, climatology and distribution of the floral zones, and productions. Part I, geology, seems to us deserving of a wider circle of readers than it is liable to obtain in its original form, and hence we have prepared this translation. The accompanying photo-engravings are sketched from Sapper's geological maps, and will serve to indicate the general distribution of the different formations as understood by that authority.

while on the contrary those in Chiapas are generally much inclined and fractured.

A. SEDIMENTARY FORMATIONS.

1. *Azoic formations*.—In addition to some very limited bands of gneiss, mica-slate, and phyllites surrounded with granite, which I observed in 1893 in the Sierra Madre, in 1894 I came



across in the first northern range of the same Sierra, near the plantations of "Piedad" and "San Vicente," another band of crystallines trending N. 7° W. and dipping 5° to the N. E. Among boulders washed down by the Aguacate River one can see gneiss, mica-slate, and phyllites, which indicate the presence of these formations in these regions and in the interior of the Sierra Madre.

On account of the total absence of means of communication in the Sierra mentioned, entrance to the interior, now practically unknown, is almost impossible; hence on the geological map I have not been able to indicate the occurrence of the Azoic formations except in a very general way.

2. *Strata of Santa Rosa*.—As I said in a preliminary report in 1893, I have adopted this term of the French geologists, A.

Dollfus and E. de Montserrat, to indicate a system of red arenaceous and slaty conglomerates which is beneath the Carboniferous limestones. I showed that the upper strata of this system in the neighboring Republic of Guatemala contain Carboniferous fossils, and although it is impossible to determine with exactness the age of the lower beds, probably they are Carboniferous or Devonian. The extent of the Santa Rosa beds is very considerable, since near Porvenir, in San Francisco Motozintla, there are important mountain chains formed almost exclusively of these beds.

These beds, like the Carboniferous limestones, are found only in the southeastern part of Chiapas. I was unable to ascertain exactly how far west they extend, but I think that they terminate at their contact with the granite rocks which form the nucleus of the Sierra Madre.

3. *Carboniferous limestone*.—The limestones and dolomites of the Carboniferous terranes have a moderate extension in the state of Chiapas, as is shown on the geological map. Their age is roughly ascertained by various fossils which I have found in the vicinity of La Nueva, Las Tres Cruces, and Palo Amarillo, which have not yet been determined (specifically).

I have also found Carboniferous fossils, as brachiopods, corals, and crinoids, near San Vicente, in the department of Comitán, in calcareous rocks, cemented together with silicon, probably in Tertiary times. At nearly all the points which I know the Carboniferous limestones lie conformably upon the Santa Rosa beds. In the vicinity of Chicomucelo and Palo Amarillo beds of limestone were seen intercalated between the slates and flagstones of the above-mentioned beds. In the preliminary report of 1894 and in the "Grundzuge der physikalischen Geographie von Guatemala" (Gotha, 1894), I have given the list of the Carboniferous fossils which up to the present date have been found in the Republic of Guatemala.

4. *Strata of Todos Santos*.—A system of sandy and slaty conglomerates of a red or reddish color, which I have termed for reasons before given the "strata of Todos Santos," are found

along the northern base of the Sierra Madre. The beds are a little inclined to the north in many places where I was able to ascertain the dip. They do not lie conformably over the Carboniferous limestones, and apparently their deposition occurred after the primary formation of the Sierra Madre, along the shores and bottom of a sea, later than the Carboniferous but before the Cretaceous, and that they have undergone few dislocations or alterations.

I cannot give any exact data on the relative age of these beds because I have found no fossils in them. Perhaps they are deposits of the Triassic period, the latter having been found in the Republics of Honduras¹ and Nicaragua.²

The formations 1 to 4 occur only in the southern part of Chiapas. The northern parts of the same state are made up of more recent sedimentary rocks, of the Cretaceous and Tertiary.

5. *Cretaceous limestone*.—In the greater part of the northern region of Chiapas are limestones and dolomites, both of the Cretaceous period. I have found *Rudistes*, *Radiolites* *sp.*, and *Spherulites* *sp.* between San Cristobal, Las Casas, and Teopisca, between Teopisca and San Lazaro, between San Bartolomé de los Llanos and San José de La Canoa, between Santa Isabel and Campana (Department of Comitán, near Comitán), between El Calvairo and Chiapa, between San Vicente and Soyaló, where I also met with some *Nerineas*, near to San Cristobal, Las Casas, and between Yochiu and Tenejapa. All these points are situated in the southern part of the Cretaceous belt.

In the northern portions of the same zone I could not find any traces of *Rudistes*, but I found remains of fossil corals in various places, as in La Puncta, the Cataté and Salvador rivers, between Sabanilla and Tila, and between Tila and Tumbalá.

These organic remains have not been examined with sufficient care as yet to enable one to say whether the limestones containing the rudistes and those containing the corals belong

¹ DR. R. FRITZGARTNER, Kaleidoscopic views of Honduras, in Honduras Mining Journal. 1891. Num. 6-8. Tegucigalpa.

² DR. BRUNO MICRISCH, Eine Reise quer durch Nicaragua, in Petermann's Mittheilungen. Gotha, 1895. Pp. 57, et seq.

to different horizons of the Upper Cretaceous, or whether they are contemporaneous formations of different appearance.

I found a fossil fish in a very fine-grained limestone which resembles the lithographic stone of Solenhofen. The ancient Indians used this stone in the construction of Palenque.

In the strata which occur in the eastern part of Chiapas I have not obtained fossils either along the road from Tenosique to Real, or on the banks of the Usumacinta and Lacantún. Yet I think that they are Cretaceous because in the eastern continuation of the few sierras of Chiniquijá, I have found in La Libertad, department of the Petén, a few badly preserved fossils which Geheimerat von Zittel, in Munich has examined and determined to be Cretaceous.

6. *Cretaceous Marls and Clays*.—Near Tuxtla Gutiérrez and Chiapa there are some deposits of marls and clays which contain fossils, as yet not well studied, of the genera *Heliopora*, *Leptophyllia*, *Goniastrea*, *Stylina*, *Cryptocænia* and *Turritella*. They are of an Upper Cretaceous horizon and more modern than the Cretaceous limestones on which they lie. I do not remember meeting with these beds in any other part of the state. The strata of this formation are a little inclined, or sometimes horizontal, as in the valley of Tuxtla and Chiapa.

7. *Tertiary*.—The Tertiary is found in many parts of the northern and central regions of Chiapa and in the southern part of Tabasco. In Tabasco the Tertiary is for the most part covered over with thin Quaternary strata.

As I have said in the preliminary report of 1893, the majority of the Tertiary is composed of marls and clays, sands and conglomerates while the limestones are of less importance.

I repeat that I found in 1893 a species of *Pecten* near Zacualpa, *Ostreas*, *Nummulites*, *Clypeaster*, and different gastropods, lamellibranchs and corals near Sacramento, the Relcario, Testaquim and Istapa, belonging, as far as have been examined, some to the Upper Miocene and some to a lower horizon. In 1889 I found near San José, department of the Comitán, remains of plants and foraminifera which Mr. C. Schwager in Munich deter-

mined as Tertiary. In 1891 I found in the alluvium of the Chixoy River Tertiary species of *Ostrea* and *Cerithium*.

In 1894 I found Tertiary fossils near Moyos, Sabanilla, Tila and Tumbalá; *Ostræ* in Tenosique, near Chinajá, in San Antonio, department of La Libertad, Chiapas; near Tenejapa and at other points. Other Tertiary fossils (Lamellibranchs) were found by D. Joaquín Zetina on the banks of the Lacanjá River, the Aguilar and other streams, and one *Ostrea* by D. Jose Tamborrel in the southern part of Tenosique.

I found in Real, department of Chilón, and in San Antonio, department of La Libertad, Chiapas, fossil plants in Tertiary terraines; but as they were not in place, I could not determine their age.

The Tertiaries are generally very much inclined; in the neighborhood of Istapa, of San Antonio, of Tenejapá and Tumbala, the strata are horizontal or of very gentle dip; they are more modern than the andesitic eruptions because they enclose pebbles of the latter, as in Burrero, district of Istapa; and in some cases the horizontal rocks lie directly above the andesite, as near to Tenejapa.

In the peninsula of Yucatan Tertiary beds predominate; and it seems that from the south to the north the successive strata become more and more recent until the Post Pliocene and Quaternary of the north coast is reached. I think that the nearly horizontal or little inclined Tertiary beds of Yucatan which I have observed, have a general, gentle slope toward the north, and that a great part of the more recent Post Pliocene beds were submerged under the sea in comparatively recent times as Heilprin concludes was the case with the "Banco de Yucatan," and quite probably the submerging took place very slowly, just as now, according to my own observations, the Atlantic coast of Guatemala is slowly sinking.

The southern parts of Yucatan show calcareous formations often containing much silicious matter. Among the limy layers, too, are occasional beds of marl and others of gypsum (alabaster). In the mountain chain of Ixconconcal, near Icaiché, I

found a number of fossils which could be used for determining the age of these deposits. The gypsiferous layers have not been seen to the north of the vicinity of Haltum.

Certainly these southern deposits belong to a lower horizon than the northern deposits which were studied by Professor Angelo Heilprin. This noted geologist has distinguished the following horizons :

(a) Limestones, gray or white in color, which can well be studied in the cave of Calcehtok, the entrance of which is 200 English feet above sea level, Fossils are rare and the following only were found: *Pecten nucleus*, *Pecten* sp., *Marginella* (sp. cf. *labiata*), *Potamides*, or *Cerithides*, *Oliva*, *Venus cancellata*. Mr. Heilprin says that the age of this limestone is Miocene or Pliocene, and not Oligocene as has been held by Alexander Agassiz.¹

(b) Limestones, red or reddish in color, lying above semi-crystalline marble or yellow limestones, very fine-grained, resembling the lithographic limestone of Solenhofen. Breccias of limestone occur at the foot of the hills. In the red limestone a *Helix* was found between Ticuli and Santa Elena, at an altitude of 300 feet above sea level, and another fossil which seemed to be a *Macroceramus*, in the cave of Calcehtok. Both these fossils are terrestrial, but it could not be said with certainty whether all the limestone is of terrestrial origin. The above limestones occur in the hilly parts of Yucatan. I notice that Mr. Heilprin does not mention the flint masses which are found in the same regions and which are used in the vicinity of Ticul for the manufacture of mill stones.

(c) The Pliocene limestone which predominates in the low regions of the north of Yucatán and which was examined by Mr. Heilprin, especially in Mérida, and between Mérida and Cal-kini, Mérida and Ticul, Mérida and Tunkás, and between Tekanto and Silam.

Professor Heilprin has found in it the following fossils :

<i>Pecten nucleus</i> ,	Tekanto, Mérida, between Mérida and Ticul.
<i>Pecten</i> n. sp.,	"

¹ Three Cruises of the Blake, Vol. I, p. 69.

<i>Anomia simplex</i> , (?)	
<i>A. Ruffini</i> ?	
<i>Plicatula filamentosa</i> ,	Tekanto.
<i>Lucina reticulata</i> ,	"
<i>Arca Adamsi</i>	"
<i>Venus mercenaria</i> ,	"
<i>Venus cancellata</i> ,	Tekanto, Mérida, between Mérida and Ticul.
<i>Marginella apicina</i> ,	"
* <i>Turritella peratenuata</i> ,	"
* <i>Turritella apicalis</i> ,	"
<i>Bulla striata</i> ,	"
* <i>Amusium Mortoni</i> ,	Izamal, Mérida.
<i>Cardium isocardia</i> ,	Mérida.
<i>Venus Listeri</i> ,	"
<i>Pecten</i> sp. ?	Between Mérida and Ticul.
<i>Pinna</i> sp. ?	" " "
<i>Lucina Jamaicensis</i> ,	" " "
<i>Lucina edentula</i> ,	" " "
<i>Cardium Magnum</i> ?	" " "
<i>Cardium muricatum</i> ,	Mérida.
<i>Murex Salleanus</i> ,	Between Mérida and Ticul.
* <i>Ostrea meridionalis</i> ,	Mérida.
<i>Arca Deshayesii</i> ,	"
* <i>Arca</i> sp.,	"
<i>Arca rombea</i> ,	"
* <i>Pectunculus</i> sp.,	"
<i>Lucina tigrina</i>	"
* <i>Lucina disciformis</i> ,	"
<i>Lucina Pennsylvanica</i> ,	"
<i>Cardium serratum</i> .	
<i>Chama arcinella</i> ,	"
<i>Venus Mortoni</i> ,	"
<i>Artemis discus</i> ,	"
<i>Macoma contracta</i> ,	"
<i>Tellina</i> sp.,	"
* <i>Fulgur rapum</i> ,	"
<i>Dolium perdix</i> ,	"
<i>Oliva literata</i> ,	"
<i>Cypræa</i> sp.,	"
<i>Pyrula reticularis</i> ,	"
<i>Siliquaria</i> sp.	"

* Not living in neighboring seas.

All these fossils are of the Pliocene; the formation is equivalent to that of Florida. Corals are rare and have not contributed to any great degree to the formation of the rocks. The fossils which I found in Mérida have not as yet been determined.

8. Post-Pliocene or Quaternary limestone, only on the northern coast and in the isolated patches in the interior of the peninsular; the remainder of the formation in the interior has been destroyed by erosion. It is characterized by *Venus cancellata* and according to Heilprin, continues northward under the sea.

B. ERUPTIVE FORMATIONS.

9. *Granite*.—Granite forms the greater part of the Sierra Madre of Chiapas; one reddish variety occurs in the northern part of that mountain chain. This granite seems to be of a later age than the Carboniferous, because the mountain chains composed of the limestone of that terrane and of the Santa Rosa beds cease abruptly upon contact with the plutonic rocks of the Sierra Madre. I have been unable to study the conditions at these points on account of the total absence of roads.

10. *Diorite*.—Diorite occurs in the northwest part of Chiapas and forms by itself a few mountain chains; it appears to be of Tertiary Age.

11. *Serpentine*.—In the region of San Francisco Motozintla various dikes of serpentine of a limited area occur between Malpaso and San Isidoro and in the vicinity of Chimalapa.

12. *Andesite*.—Andesite eruptions have been found only in the State of Chiapas; in the northwest, andesitic hypersthene is found forming a mountain chain of considerable altitude (more than 2000 [meters?]), and in the central part of the state hornblendic andesite occurs forming the chains to the north and southwest of San Cristobal, Las Casas and the picturesque chains of Mispilla and San Bartolomé de los Llanos, besides many dikes of minor importance. These andesites made their eruptions successively during the Tertiary epoch and before the formation of the Neo-tertiaries of Burrero near Istapa and Tene-

japa, but probably after the dislocations of the beds of the Upper Miocene of Sacramento. In the Sierra Madre there were other great eruptions. I have been unable as yet to mark out the westward limit.

VOLCANOES.

The only volcano known in the state of Chiapas is Tacaná (3990 meters), through the apex of which passes the dividing line between the Republics of Mexico and Guatemala. Its latest eruption took place in 1855.

CARLOS SAPPER.

[Translated by C. Joaquina Maury and G. D. Harris.]